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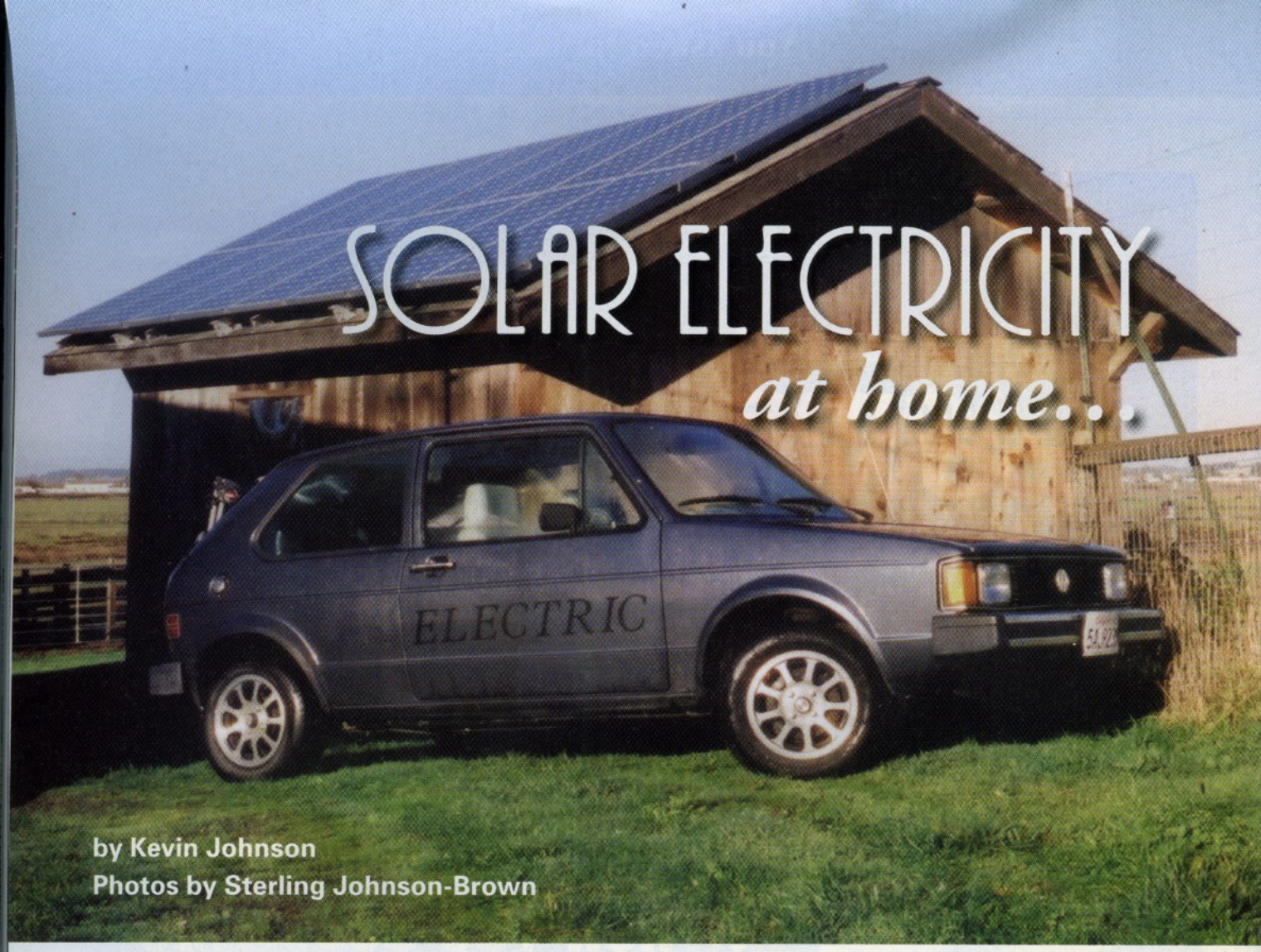
SOLAR ELECTRICITY *at home...*



by Kevin Johnson
Photos by Sterling Johnson-Brown

Green wheels: This Volkwagen Rabbit, converted to run on electricity, recharges its batteries from a grid-tied solar-electric system.

Our car is powered by the sun. It costs less than half as much to operate as some of the most efficient gasoline- or diesel-fueled cars, and produces zero tailpipe emissions.

Our family had been living a simple rural and remote life using very little energy—except for the vehicle we used to transport us to town, work, and school on a daily basis. Three years ago, we made a commitment to fulfill the long sought-after dream of environmentally friendlier transportation, following a move closer to town.

We came to a point where being energy conscious in our home, but driving—and burning fossil fuels—seemed completely out of balance. Over many years, we've endeavored to increase our energy independence through conservation, efficiency, and lifestyle changes. With the addition of the electric vehicle (and our solar-electric system), we were able to bring our transportation needs into this fold.

Electric Attraction

Watching the electric vehicle (EV) rallies and races at renewable energy fairs in nearby Willits, California, in the early 1990s sparked our interest. We built our knowledge base by attending a number of conversion workshops throughout northern California over the years, taught by EV experts Mike Brown and Shari Prange of Electro Automotive, and others. Shortly after the second Persian Gulf war began in early 2003, we decided that it was time to begin our search for a vehicle that would fulfill our environmental goals and meet our family's transportation needs.

We felt that our country was going to war to expand America's oil interests in Iraq and we didn't want a part in it. There was no better time for us to make the change from fossil fuel to solar energy for our transportation needs. We decided that purchasing an already converted vehicle would be our best bet for our first electric experience, so we shopped for a conversion with reliable and standardized components.

In February 2003, through the Oregon Electric Vehicle Association's Web site, we found an already converted Volkswagen "VoltsRabbit." I contacted the seller, an electric

vehicle enthusiast from Portland, Oregon, and purchased a one-way bus ticket to Portland from our hometown in northern California. I bought the car for $4,200, and rented a truck with a trailer to bring it home.

The car, which has turned out to be a jewel, is a 1984, two-door, four-passenger VW Rabbit. It needed cleaning and a new headliner, but was otherwise in good working condition. It was converted several years prior to our purchase, but had been stored for a couple of years unused. Its sixteen, 6-volt Exide golf-cart batteries were still retaining a charge and continued to work for the next few years. This surprised us, since the car had been sitting for so long. It came with a 120-volt K&W onboard charger and an Advanced 8-inch DC motor with a Curtis 1221 controller. The conversion had been done by a mechanic with an Electro Automotive kit.

Solar Charging

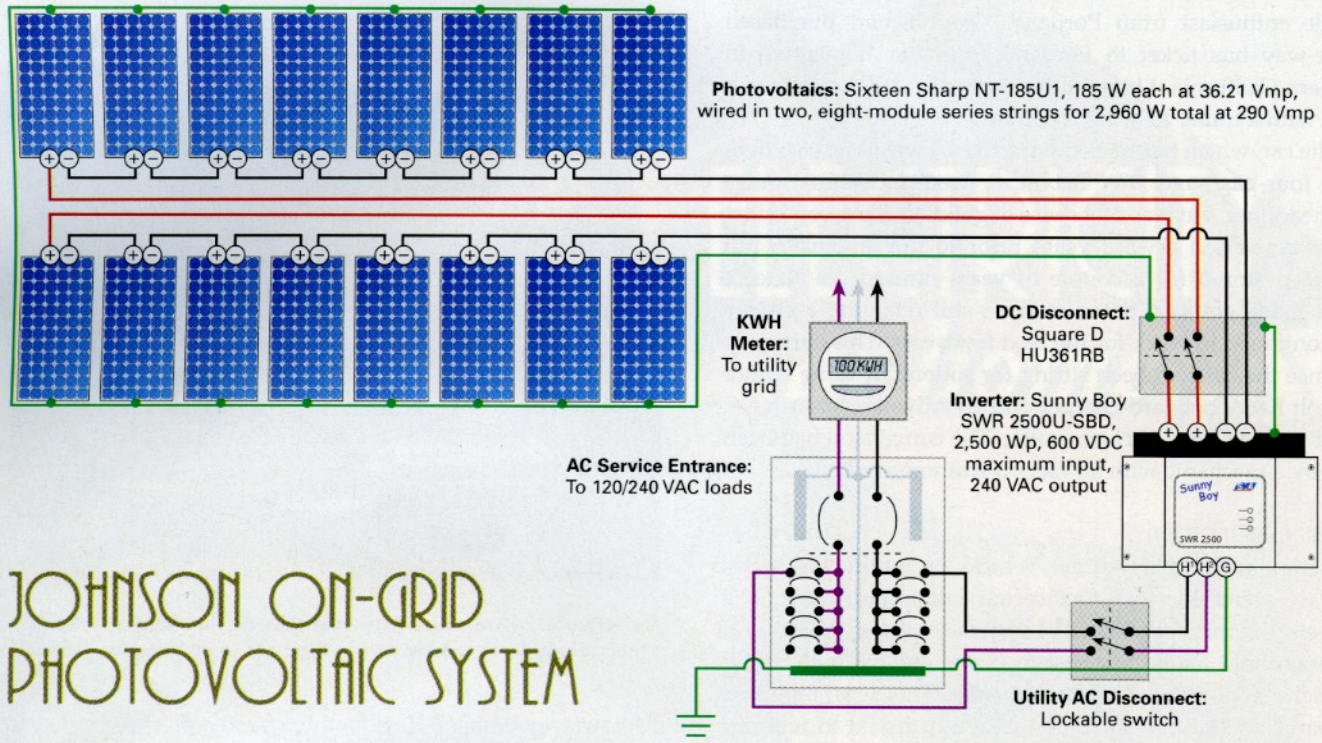
We temporarily charged the vehicle on utility electricity until we were able to refinance our home and invest in a solar-electric (photovoltaic; PV) system to power the car and our household loads. The cost to power the car with utility electricity was about 4 cents per mile. This was stunning, compared to 14 cents per mile that we had paid to fuel our gasoline-engine car. Even a car with gas mileage of 40 mpg would cost more than twice that of the electric to drive, at about 8.5 cents per mile.

Through conservation and efficiency measures, we decreased our household electrical needs to less than

VoltsRabbit owners Lisa Brown and Kevin Johnson promote EV technology by regularly taking their car to community events.

5 kilowatt-hours per day for our family of three prior to installing our PV system. We had just finished restoring our old farmhouse, which we retrofitted with conservation and efficiency in mind. The 16-cubic-foot Sun Frost refrigerator, efficient Maytag Gemini glass-top electric stove (with a small oven), Eemax electric, on-demand, under-counter water

The VoltsRabbit recharges its batteries from typical grid electricity or, in this case, from the Johnsons' solar-electric system.



JOHNSON ON-GRID PHOTOVOLTAIC SYSTEM

Tech Specs

Overview

System type: Batteryless, grid-tie PV

Location: Arcata, California

Solar resource: 4.4 average daily peak sun-hours

Production: 300 AC KWH per month

Utility electricity offset: 90+ percent

Photovoltaics

Modules: 16, Sharp, NT-185U1, 185 W STC, 36.21 Vmp

Array: Two 8-module series strings, 1,480 W STC each, 2,960 W STC total, 289.68 Vmp

PV DC disconnect: Square D HU361RB

AC disconnect: Cutler-Hammer DG-221-URB

Array installation: Direct Power & Water mounts installed on south-facing roof, 30-degree tilt

Balance of System

Inverter: SMA America Sunny Boy, SWR 2500U-SBD, 2,500 Wp, 600 VDC maximum DC input voltage, 234–550 VDC MPPT voltage window, 240 VAC output

System performance metering: Built-in inverter display and datalogging; utility KWH meter

heater for the kitchen sink, and compact fluorescent lighting throughout the house are the techno fixes we provided, as well as adding insulation and installing double-paned windows.

Additionally, we effectively eliminated phantom loads (standby electricity drawn by an appliance when plugged in but turned off) by unplugging all electrical items when not in use and using power strips for the computers. We then sized our PV system to meet our actual needs—about 5 kilowatt-hours per day for the house and 5 kilowatt-hours per day for the car.

Our 2.9-kilowatt grid-tied system was installed on our shed with our local solar electrician, Roger, at the helm. John Davis, Rowan Gratz-Weiser, Roger, and I worked on the installation, which took about three days. I was able to work off a significant amount of the labor cost by being involved in the installation and trading out my labor on other projects.

Upgrades & Benefits

Since purchasing the car in 2003, we've had to replace the original batteries that came with it. I decided to replace the Exides with Trojan T-105s. These were available locally at a good price (about $900 total) and are a dependable, long-lived battery. I found that the individual battery caps the Trojans use tend to have no leakage, keeping the battery tops cleaner.

At the same time, I decided to upgrade the 120-volt charger to a faster and more efficient 240-volt Zivan charger that has an automatic shutoff and equalization features for the batteries. The new charger takes 4 to 5 hours to completely recharge the batteries, compared to about 8 to 10 hours for

the 120 V charger. Aside from adding a couple of gallons of distilled water to the batteries every few months, the electric car requires very little maintenance.

An added feature of the electric car that we hadn't really considered, but find very useful, is the mobile battery bank it provides. When the grid goes down, as it often does here in the winter, we can use the car's stored energy via a small 400-watt inverter on the car's 12-volt auxiliary battery, which is kept charged via a DC-to-DC converter from the main battery bank. We operate a small store in town, and can run our cash register, credit card machine, stereo, fax machine, and lights during utility outages. At home, we can plug into the car to watch TV or have some lighting for our evening tasks if the grid is down.

Resurrecting EVs

Insistence by the California Air Resources Board that electric vehicles (EVs) could be the solution to California's air-pollution problems and the development of the ZEV (zero emissions vehicle) mandate in 1990 resulted in the development of General Motor's EV1 and similar electric vehicles.

EVs suffered a setback by the elimination of this mandate in 2003 and the crushing of many of these cars, but the electric car has not been killed—far from it. Its fate may best be left for us to bring to the forefront as an integral part of our renewable energy future. The electric car lives in our driveway and in the driveways of many today, and its time has come.

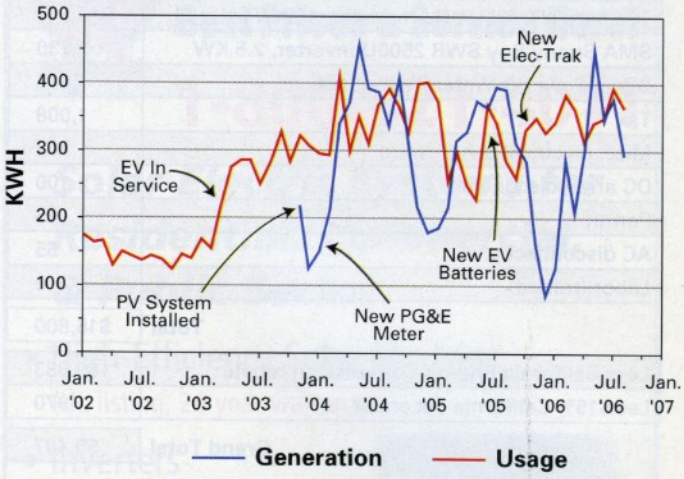
I work with a small group of EV enthusiasts—the Humboldt Electric Vehicle Association—to encourage and aid people in our community who are interested in purchasing or converting a car to electricity. Our goal is to replace gasoline-engine cars on the road with electric vehicles.

One of the best things that EV activists can do is to connect with other EV activists in their communities and develop support networks. It helps to meet on a regular basis with this group of folks to share information and build upon ideas for community outreach. Among the ideas we've worked with are:

- Bringing vehicles to fairs, car shows, parades, schools, and other events to showcase electric vehicles.
- Organizing workshops or conversion projects, and inviting the public.
- Working with local and regional governments to establish electric vehicle charging stations.
- Writing articles and letters to the editor about EVs.
- Sending out press releases when opportunities arise.
- Establishing a Web site for our local EV group.
- Encouraging local governments to incorporate EVs into their fleets.

In the end, *driving* your vehicle is absolutely the best way to let others know that EVs are viable, affordable, and user friendly.

System Generation & Usage



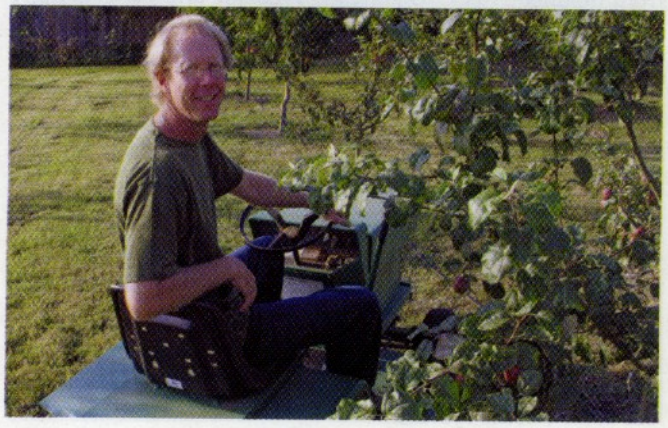
For long-distance trips (beyond the car's 40- to 50-mile range), we drive a 1985 VW Jetta that gets 40 to 45 mpg. We run the Jetta on locally produced biodiesel made from restaurants' waste cooking oil.

But the Jetta spends most of its time in our driveway, since the electric car is the easiest and most enjoyable car to use for our daily errands. Driving the electric is simply a matter of turning the key and going down the road. There is no start-up, no warm-up, no fumes, no gas stations, and no engine noise to contend with. When you stop the car, it is silent. When you coast down a hill, the car uses no energy.

Electric Tractor

The newest member of our electric fleet is a 1970s General Electric Elec-Trak tractor (36-volt) with a 42-inch mower deck. Many years ago, our friend David Katz from Alternative Energy Engineering purchased a number of Tennessee Valley Authority's electric vehicles, including an Elec-Trak. I expressed to him by chance that I was looking for an Elec-Trak, not knowing he actually had one, and he offered it for free, providing I hauled it away!

The GE Elec-Trak tractor charges its batteries from the solar-electric system and keeps the orchard understory mowed to perfection.



System Cost Analysis

System Costs	Cost
16 Sharp NT-185U1 PV modules, 185 W	$10,814
SMA Sunny Boy SWR 2500U inverter, 2.5 KW	2,230
Direct Power & Water PV mounts	1,206
Tax	1,008
Misc. electrical & hardware	302
DC array disconnect	100
Permit	85
AC disconnect	55
Labor (traded)	0
Total	$15,800
Less California Energy Commission rebate	-$9,333
Less 15% California tax credit	-970
Grand Total	$5,497

Simple Payback	Amount
Recorded annual PV production (KWH)	3,585
Actual annual household electricity usage (KWH)	1,825
Present cost of electricity ($ per KWH)	$0.148
Annual household electricity costs ($)	$270
Annual mileage	5,000
Gasoline price ($ per gallon)	$3.39
Annual fuel savings (EV vs. 25 mpg gas engine)	$678
Payback, Considering Both Household & Vehicle (Yrs.)	5.8
Payback Without Vehicle, If Home Consumed All PV Production (Yrs.)	10.4
Payback Without Vehicle, Considering Actual Household Consumption (Yrs.)	20.4

The tractor had been sitting out in the weather for many years, wasn't running, and was very rusty. First I checked the main drive motor by hooking a 12-volt battery up to it to see if the motor would spin. It did! The mower deck has three motors and the bearings were shot on all of them, so I took them off and had them repaired at the local electric motor shop.

I downloaded the repair manuals and wiring diagrams from the Elec-Trak Owners Club Web site and painstakingly pieced everything back together with the help of Nick Johnston, a friend and fellow EV enthusiast. Once I knew the tractor was operable, the entire machine was stripped of its rusty yellow paint by hand. Parts that were removable were pulled and sandblasted. The bare metal was primed and recoated with a nice John Deere green. Six new 6-volt Trojan T-105 batteries completed the restoration.

Elec-Trak tractors once had numerous accessories, including a snow blower and rototiller, but ours came with just a mower deck. The tractor helps out on our farm, hauling horse manure and compost with a small trailer, and mowing the lawn and orchard. Like our VoltsRabbit, it is charged by our solar-electric system.

PV & EV Payback

Charging our electric car and mower with solar electricity from our PV system decreases the payback time for our solar-electric system, since the money saved by not buying gasoline can be included in this calculation. Our system cost was only $5,497 (remember, I traded labor!) after we claimed the California Energy Commission's "Emerging Renewables Program" rebate, which we hit at the peak refund period, and the State of California's Solar Energy System Credit (15% of the amount paid for the system, after the CEC's rebate). The electric car replaced a gas-engine Toyota Tercel station wagon that was getting about 25 mpg. For the 5,000 miles we drive each year, we save between $500 and $700 on fuel costs by driving our electric car instead of our gasoline-engine station wagon or biodiesel-fueled VW Jetta. Added to the annual electricity cost savings of $270 for our household, our solar-electric system saves us almost $1,000 each year.

At this rate, we will recoup our PV system costs in less than six years. The payback period will probably become even shorter, as gasoline and electricity prices continue to climb. The combined costs of our car and solar-electric system was far less than the cost of a typical new car. Plus, factoring in the electric car's savings on fuel costs cuts the PV system's payback time by one-third to one-half (see cost table).

Knowing that our electric car is both a smart environmental and economic choice heightens our enjoyment of driving it. Driving an electric car is sensible and forward-thinking. Our little VoltsRabbit makes an impression on all who see it. It reminds people that there is a solution to the oil dependency that plagues us. In some way, I sense that it provides some hope.

Access

Kevin Johnson & Sterling Johnson-Brown, c/o Solutions, 1063 H St., Arcata, CA 95521 • 707-822-6972 • mingo@tidepool.com

PV System:

Roger • 707-826-9901 • Solar-electric system installer

Direct Power & Water • 800-260-3792 • www.power-fab.com • PV rack

Sharp Electronics, Solar Systems Division • 800-SOLAR06 • www.sharp-usa.com/solar • PVs

SMA America Inc. • 530-273-4895 • www.sma-america.com • Inverter

EV Resources:

California Air Resources Board • www.arb.ca.gov/msprog/zevprog/zevprog.htm

Electro Automotive • 831-429-1989 • www.electroauto.com

Elec-Trak Owners Club • www.elec-trak.com

EV Trading Post • www.austinev.org

Humboldt Electric Vehicle Association • 707-822-6972 • www.heva.org